The $Z \to b\bar{b}$ Search at CDF-II

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Summary

- Introduction and motivation
- Run I searches
- The new CDF detector
- Extrapolation to 2 fb^{-1}
- Possible trigger improvements
- Conclusions

Introduction and motivations

The $Z \to b\bar{b}$ process offers the possibility to determine the resolution reachable in the di-jet mass spectra of b-jets.

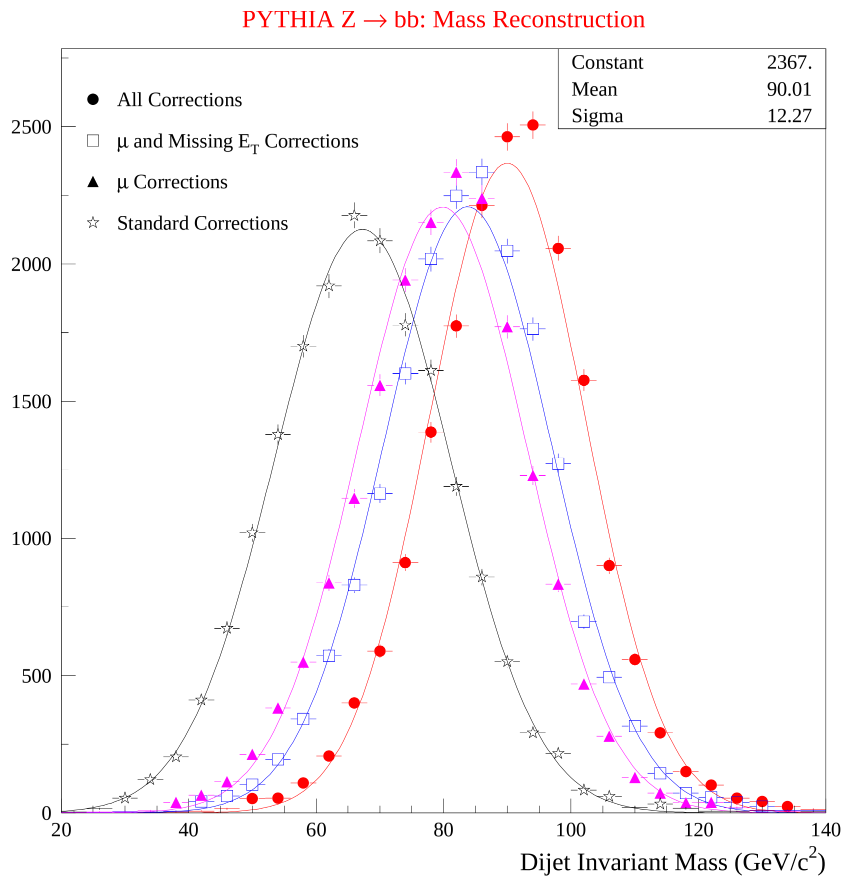
The study of this known channel offers the possibility of:

- test and tune b-specific **jet corrections**;
- extracting the **b-jet energy** scale and its uncertainty.

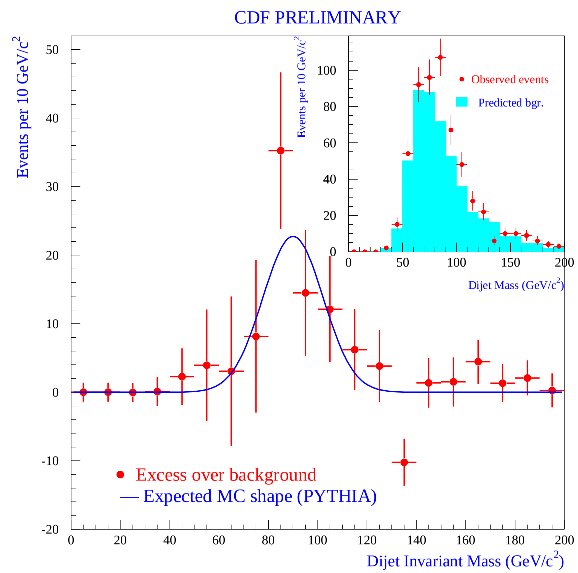
This information can be used in different analyses involving events containing b-jets, such as:

- **Associated Higgs production**;
- $t\bar{t}$ **production**.

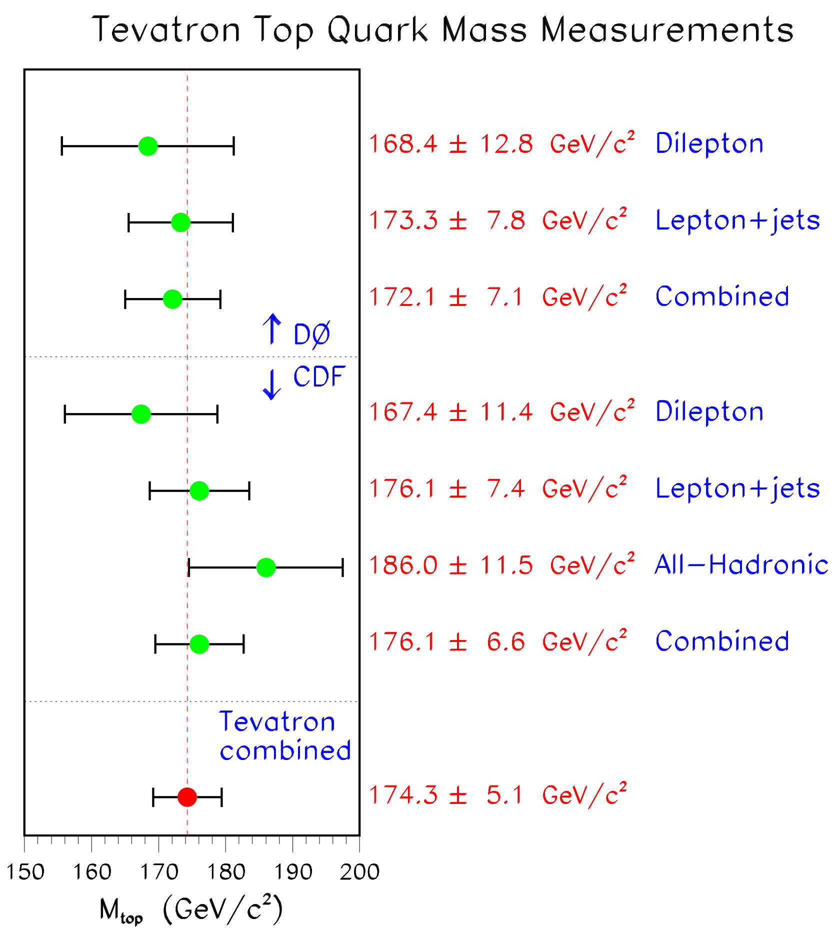
Run I: Observation of the $Z \to b\bar{b}$ signal



▶ Specific jet energy corrections (based on muon momentum, the $\not{E}_T$ and the jet charged fraction) allowed to obtain a better resolution on the $Z \to b\bar{b}$ mass peak. They are found to be equally useful for different $b\bar{b}$ resonances such as the Higgs boson.



The Top mass

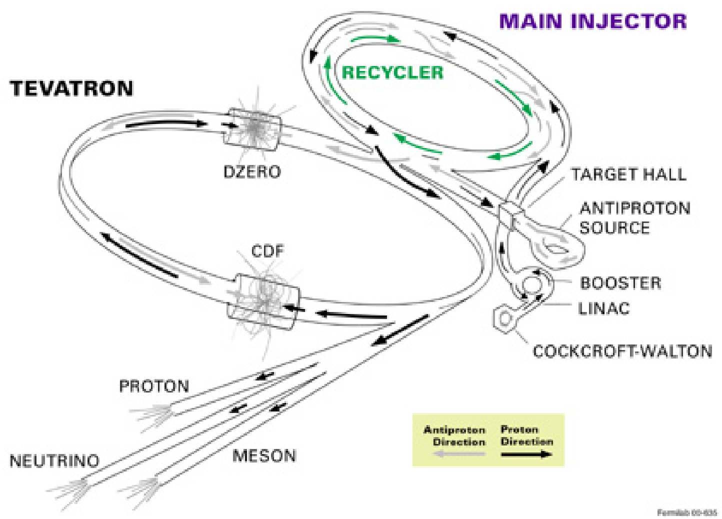


Systematics on M_t (CDF)	GeV/c^2
Soft gluon + Jet E_T scale	3.6
Different generators	1.4
Hard Gluon Effects	2.2
Kin. and Fitting Methods	1.5
b-tagging bias	0.4
Bkg spectrum	0.7
MC statistics	0.8
Total	4.8

- The uncertainty on the b-jet energy scale affected the top mass measurement as the dominant source of systematic error.

- We can use the high statistics available with Run II for a better determination of the b-jet energy scale using the $Z \to b\bar{b}$ channel.

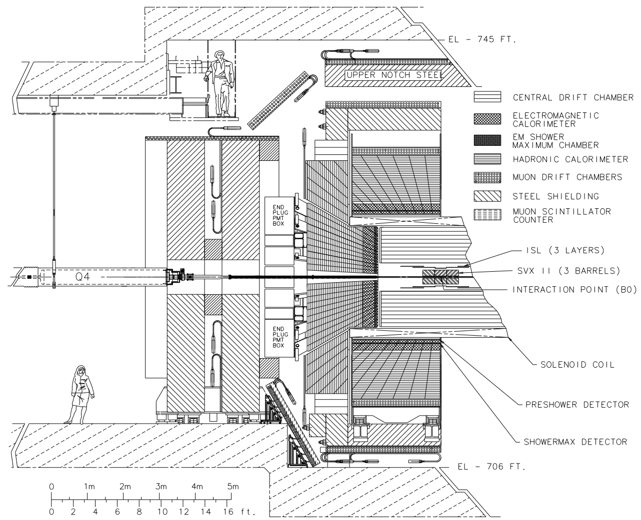
The CDF experimental complex



← Accelerator complex

CDF is a multi-purpose detector specifically designed for the studies of $p\bar{p}$ interactions.

Inside a large drift chamber is a 7-layers silicon detector crucial to detect secondary vertices from heavy flavour decays. ↓



- $\sqrt{s} = 1.8\ TeV$ Run I
- $\mathcal{L}_{ist} \sim 10^{31}\ cm^{-2}s^{-1}$

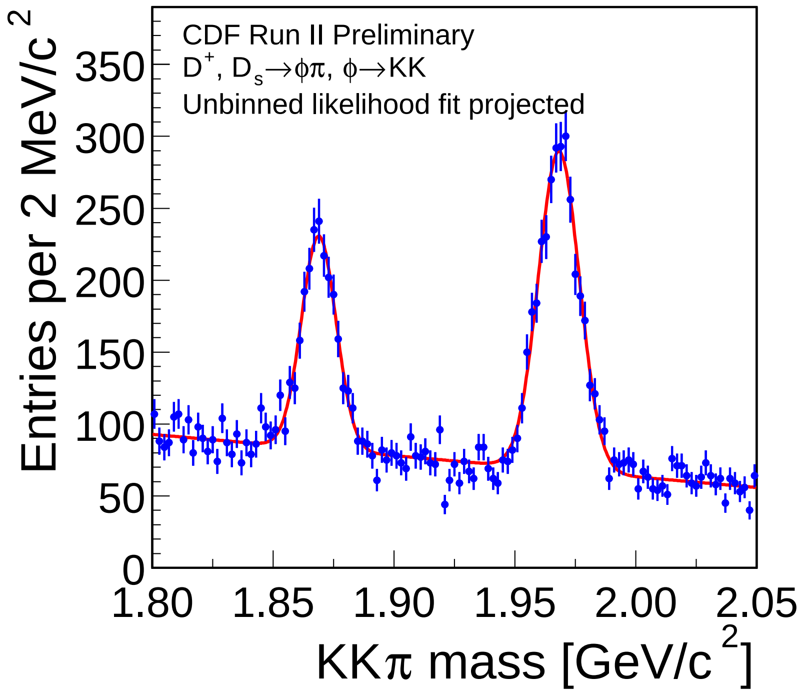
- $\sqrt{s} = 2.0\ TeV$ Run II
- $\mathcal{L}_{ist} \sim 10^{32}\ cm^{-2}s^{-1}$

New Instruments for B-Tagging

During Run II, CDF can identify secondary vertices inside jets in an extended range in pseudorapidity.

A new trigger system, SVT, is available for the online identification of hadronic events with displaced tracks with respect to the interaction point.

SVT allows measurements of P_T, ϕ and impact parameter d of charged tracks inside the region $|\eta| < 2$ with a resolution of $\sigma_d \sim 45\ \mu m$.



With low statistics (11.6 pb^{-1}) CDF already produces its first physics results.

$$m(D_s^\pm) - m(D^\pm) = 99.28 \pm 0.43 \pm 0.27\ MeV/c^2$$

$$(\text{PDG 2002: } 99.2 \pm 0.5\ MeV/c^2)$$

SVT-based Triggers for $Z \rightarrow b\bar{b}$ search

In Run I, to see $Z \rightarrow b\bar{b}$ decays, we triggered on muons.
In Run II, with SVT we trigger on the impact parameter of charged tracks.

This allows to collect large samples of unbiased b-enriched dijet events.

Current Triggers at work

Z_BB ($\sigma_{trg} \sim 12\ nb$)

- 2 jets with $E_T > 10\ GeV$
- 1 SVT+COT trk with $P_T > 4\ GeV$
- 1 SVT+COT trk with $P_T > 6\ GeV$
- both tracks with $120\mu m < |d_0| < 1mm$
- $\Delta\phi_{tt} > 150°$

efficiency on signal $= 1.32 \pm 0.05\%$

HIGH_PT_BJET ($\sigma_{trg} \sim 120\ nb$)

- 2 jets with $E_T > 20\ GeV$
- 2 SVT+COT trks with $P_T > 2\ GeV$
- both tracks with $100\mu m < |d_0| < 1mm$

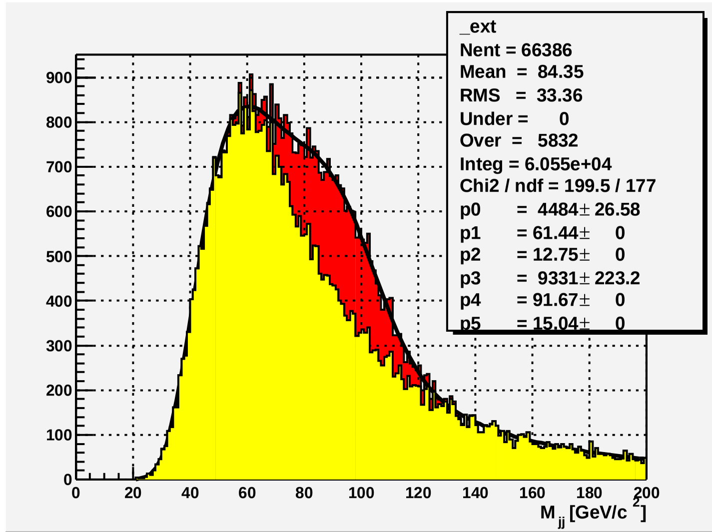
efficiency on signal $= 7.11 \pm 0.18\%$

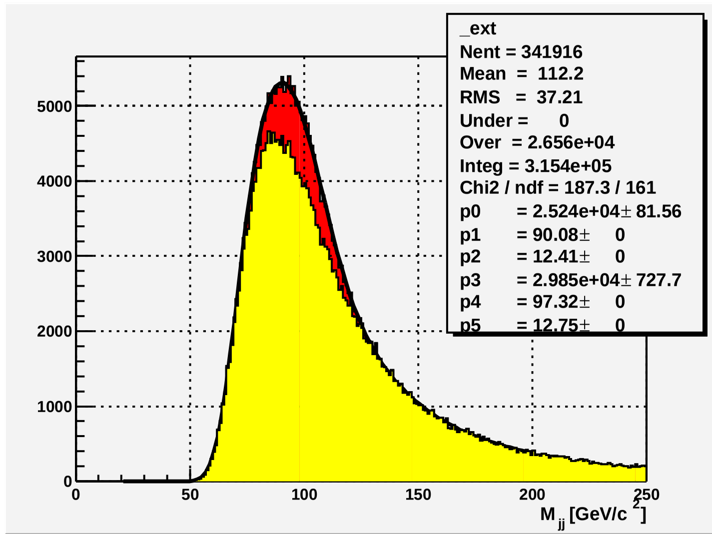
Extrapolations to 2 fb^{-1}

▶ Early data from Run II have confirmed the potential power of the SVT-based triggers in collecting heavy-flavour samples.

▶ On the offline side, b-jet tagging is to date under optimization but a development version is available to get first hint for analysis tools.

▶ First data collected with previously described $Z \to b\bar{b}$ trigger allow us to get some extrapolation on how the actual trigger running conditions might be enough for a b-jet energy scale determination better than 1%.





Possible Improvements of the Z_BB trigger

First results based on extrapolations show that the current Z_BB trigger setting are *marginally* sufficient to allow for the extraction of a jet energy scale precise enough to bear an impact on the top mass.

▶ New trigger setting aimed at increasing the efficiency on signal events while keeping the cross section under control have been studied in different scenarios.

Optimized cuts for 100 nb at Level 2 and 15 nb at Level 3

Level 2 and 3 Requirements	Cross Section	Efficiency	Eff. (+ 2 tags)
Two SVT Reconstructed Tracks $P_T^{SVT} \geq 2.5\ GeV/c$, $\lvert d_0^{SVT}\rvert \geq 150\ \mu m$, $\lvert d_0^{SVT}\rvert \leq 1\ mm$, $\Delta\phi^{SVT} \geq 150^o$,	$36 \pm 3\ nb$	$3.7 \pm 0.1\%$	$1.60 \pm 0.07\%$
Two SVT+COT Tracks $P_T^{Trk1} \geq 2.5\ GeV/c$, $P_T^{Trk2} \geq 3.5\ GeV/c$, $150\ \mu m \leq \lvert d_0^{Trk}\rvert \leq 1\ mm$, $\lvert\eta^{Trk}\rvert \leq 1.2$, $\Delta\phi_{tt} \geq 150^o$, Two Jets, $\lvert\eta^{jet}\rvert \leq 1$, $E_T^{jet} \geq 10\ GeV$	$14 \pm 2\ nb$	$2.16 \pm 7\%$	$1.13 \pm 0.05\%$

Conclusions

▶ The $Z \to b\bar{b}$ channel should be cosidered as a milestone for all future analyses involving the use of high-P_T b-jets

- ▶ it provides the possibility of tuning and testing specific b-jet energy corrections
- ▶ as a calibration channel it can be used to determine the b-jet energy scale and its uncertainty.

- Our first results show that the current Z_BB trigger settings are too tight to allow a determination of a b-jet energy scale to 1% (the goal for a 2% top mass measurement).
- Optimized trigger settings appear to reduce sizably the uncertainty on the energy scale with a modest increase of the trigger cross section.
- Right now our proposal for an optimized Z_BB trigger is running in a Test-Trigger-Table